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Abstract

Information sharing within enterprise wide is regarded as one of important tools to gain the competitive advantage, especially under the business strategy of customer relationship management (abbr. CRM). However people are often confused by same conception with different name or title in same or different context when discussing something about business. Therefore a bridge for information understanding and sharing based on the semantic relation is desired to help people form unique conception when the same thing is referred. Ontology as a new mechanism of information sharing in the field of information system and artificial intelligent is just this bridge and has been generally studied in recent years to unify the conception and termination for some domain. The paper attempts to explain how the customer ontology, one of the domain ontology, works in CRM. By doing so a detailed process including four steps according to UML methodology is firstly introduced to find out the concepts and terms relevant to customer in CRM as many as possible by brainstorm. And then meta-terms with five elements are introduced to explain and define the concepts and terms in order to facilitate formalization of them. Next description logic, a tool of artificial intelligent, is employed to formulate the concepts and terms according to the customer ontology with seven meta-elements. Meanwhile some formalized examples of those concepts and terms are demonstrated to imply the feasibility of the mechanism. Finally the paper indicates the big potential application for customer ontology and also shows some directions to improve the availability of customer ontology.

Keywords: Customer Ontology, Customer Relationship Management, Description Logic, formalization, Conceptulization, Meta-terms

1. Introduction

Nowadays the business environment becomes more variable than ever. 3C, namely customer, change and competition, is used to explain these features. This indicates that customer resources and customer knowledge are showing more value than before. Enterprises should open a new vision, the view of strategy of customer relationship management (abbr. CRM), to introspect their business and the surrounding market environment. It also predicts that business activities based on customer demand could win bigger competitive advantages for one enterprise.

As one of bases of the implementation of CRM strategy, customer information sharing

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should be firstly established in order to form a unique communication platform. Many technologies, such as COM、CORBA and Agent, have been developed to solve the technical problem of information sharing (Filman, 2000). Though these technologies behaved very well in information sharing by the mode of message exchanging, objective or component inter-referred and inter-operation among different system they remain syntax sharing basically and cannot describe customer information semantically as well as express implied axiom, facts, judgments and rules relevant to customer knowledge already existed in the information system. As a result the structured information inferred from knowledge base or other information sources is unavailable as yet. Of course some new and useful knowledge about customer can hardly produced or induced. More important, information sharing not based on semantic relation often leads to people confused by same conception with different name or title in same or different context when discussing something about business.

Therefore many problems about information sharing with semantic view still remain unsolved completely. The cause to the situation lies in the mode of information sharing. In fact most mistakes of information sharing based on syntax relation are inevitable when its function mechanism is taken into accounted.

As a substitute for the mode of information sharing another approach, ontology for example, based on semantic relation has gained more attention from researchers (Gruber, 1995). Since this mode of information sharing can provide a uniform communication platform as well as avoid the mistake to the same concepts with different name or title in different context much efforts have been made to design this effective tool to mediate information sharing in terms of this mode within or beyond one enterprise.

Ontology as a new mechanism of information sharing has been originally used in philosophy sphere, where it indicates the systematic explanation of Existence. There it means an explicit and formalized normative specification to a set of shared conceptual model (McGuinness, 2002). As an important instrument of modeling domain conception it is invented in recent years to unify the conception and termination for some domain and can provide formularized description for domain knowledge. Now ontology is gaining a specific role in information system and Artificial Intelligence as an explicit specification of a conceptualization (Guarino 1995).

Literatures about ontology have revealed that there are many fields that ontology can be applied to. Uschold firstly summarized the application of ontology from three aspects: communication, inter-operability and systems engineering (Uschold, 1996). TOVE (TOronto Virtual Enterprise) ontology to model virtual enterprise has been developed to provide shared terms for all kinds of software in the enterprise (Gruninger and Fox, 1995). CYC ontology organized by module has been established in CYC project to construct a basis for common sense reasoning (Lenat, 1990). Enterprise ontology, another remarkable instance, has integrated other enterprise modeling methods and provided some useful tools to help analyze business activities (Uschold, 1998). KACTUS derived from ESPRIT project can support to construct an ontology applied to product knowledge reuse (Schreiber, 1995). In addition ontology representation such as Ontolingua system and integration with current standard such as CORBA and STEP are also explored to exhibit those obtained fruit and research interests (Uschold, 1998 and Guarino, 1997).

As another application of domain ontology customer ontology is developed in this paper to support information sharing under CRM framework. The rest of the paper is organized as following. Section 2 firstly describes the conceptualization process thought as the premise for

building ontology according to UML logic and obtains correlative terms and concepts as many as possible by four steps. And then those terms and concepts are explained and defined by meta-terms developed by our project team so that can facilitate the formalization of customer terms in CRM. Section 3 firstly explains why Descriptive Logic (DL) is selected as the tool to formalize customer terms. And then the formalization process with DL is demonstrated by instances. Finally the big potential applications for customer ontology and some directions to improve the availability of customer ontology are briefly discussed in section 4.

2. Conceptualization of Customer in CRM

2.1. Discovery Process of Customer Terms

Conceptualization of customer in CRM is the prerequisite of modelling customer ontology according to ontology engineering. However the word "Customer", including not only group customer and individual customer but also internal customer and public customer, is frequently used in so many occasions that the mission to extract the relevant concepts and terms is impossible considering the limitation of paper size unless the word is limited to one field, individual customer for example. If so, those concepts and terms related to wholesalers, retailers and their activities may not be covered under the customer conceptualization process. Thus the following discussion can be focused on the main aspects. Even though the essence of conceptualization process remains unchangeable.

In order to exhibit the process clearly a structured approach derived from UML methodology is employed to scheme the following steps shown as figure 1. Now let's give a detailed explanation to every step.

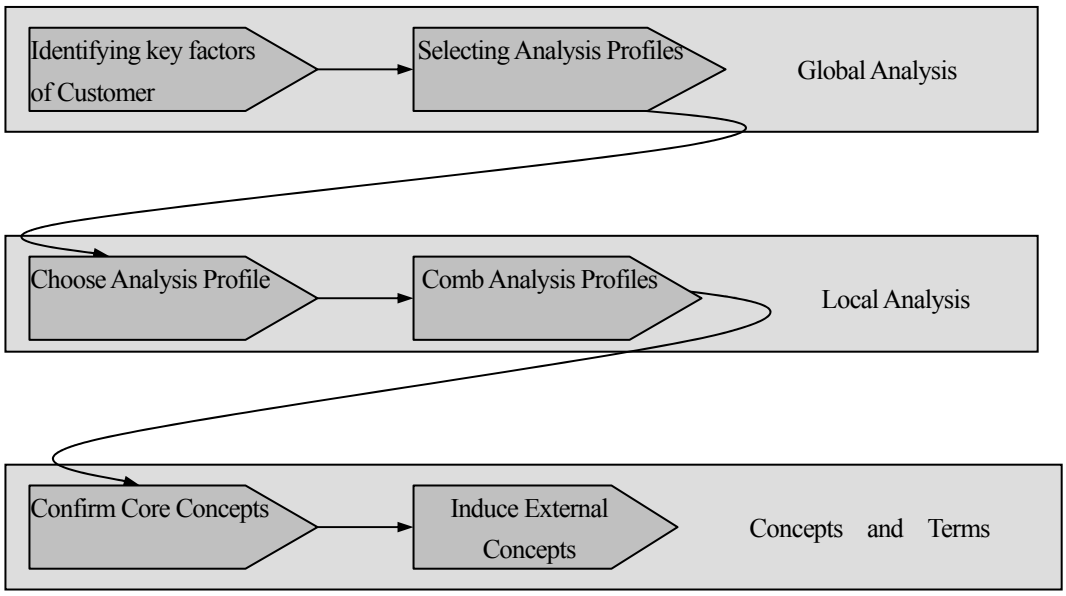

Fig.1 Discovery Process of Customer Terms

step1. Global Analysis

Global analysis means to construct architecture of conceptualization and identify the key abstract factors influencing the architecture. These abstract factors can be named as different analytical profiles implying many concepts and terms. The paper extracts 4 analytical profiles, viz. type、feature、behaviour and state by summarizing and refining much of related literatures. These

consist of the scope of conceptualization.

step2. Local Analysis

Local analysis concentrates on one of the analytical profiles mentioned above and acquires the concepts and terms as many as possible in this profile by some techniques.

Once the step is taken one of the analytical profiles is selected and some techniques such as brainstorm or Delphi are used to collect the concepts and terms pertain to the profile. After that all of the concepts and terms need to be cleared up in order to remain the valid, delete the invalid and supplement some external ones according to the associated relationships among the remaining and their capability to respond to the tasks. Here the judgement between the valid and the invalid lies in the fact whether they close to individual customer in CRM and will be frequently used. Of course those valid concepts and terms also appear in the both terminology sets and terminology definition sets which are two elements of ontology model.

When the identification finished most of the concepts and terms pertain to some analytical profile is found out. Supposed the whole process above is iterated most of the concepts and terms pertain to customer domain in CRM can be ultimately found out.

In this paper the searching process of concepts and terms pertain to customer is the same as what demonstrated above. As a result as possible as many the relevant terms and concepts are discovered utilizing brainstorm and experts interview. As for external concepts and terms, a good blueprint enterprise ontology developed by AI Institute, Edinburgh University can be referred since some of concepts and terms in this ontology related to individual customer in CRM.

step3. Concepts and Terms Organization

After finishing the selection all of valid concepts and terms belonged to the four analytical profiles are completely reserved. Herein the external concepts and terms in every profile are aggregated solely so that the formalization of them and establishment of customer ontology become easier later.

Thus all of concepts and terms are normatively listed in table 1 which summaries most of the component in customer domain (Xiao, 2003).

Table1 Concepts and Terms of Customer Terms List

Customer Type	Current Customer, Potential Customer, Customer, Consumer, Dealer, New Customer, Lost Customer, Switched Customer, Loyal Customer, Satisfied Customer, VIP Customer, Advocatory Customer
Customer Feature	Age, Gender, Job, Salary, Height, Weight, Education, Position, Nationality, Title, Family Address, Family Members
Customer Behaviour	Transaction, Purchase, Ratio of Consumption, Information Acquisition, Iterative Purchase, Cross Purchase, Customer Feedback, Words of Mouth, Customer Switch, Touching point
Customer State	Demand, Preference, Satisfaction Degree, Loyalty Degree, Customer Lifetime, Customer Lifetime Value, Propensity of Customer Switching, Perceived Value of Customer, Perceived Quality of Customer, Perceived Price of Customer
External Concepts	Product, Product Information, Transaction Price, Vendor, Competitor, Ownership, Customer Relationship,

Remarkably, these concepts and terms concerning individual customer domain in CRM should be not only as comprehensive as possible but also recognized as the only representation format by experts. Contrarily, the concepts framework with five elements is just convenient for

understanding and demands no such requirement and has no relationship with formalization of customer ontology. However such the both requirements uniqueness pertain to the representation and irrelevance pertain to the framework of concepts and terms should be just the reflection of domain conceptualization.

2.2. Description of Customer Terms

2.2.1. Meta-Terms of Customer Terms

Generally, facing so many concepts and terms modelers hardly establish so good customer ontology that is considered as the base of information system modeling in enterprise. Because there exists much of superposition and amphibology at connotation among those concepts and terms listed in table1. As a result the quality and availability of the ontology are difficult to be guaranteed. On the other hand although the representation of the concepts and terms is stable it is possible to supplement some new concepts and terms during application.

Therefore meta-terms, resembling to meta-data that mean data of other data, are introduced to explain the definite meaning of each concept and terms and simultaneously to reveal the inter-relationship among them. Meta-terms refer to the terms of other terms and are the abstract of one domain (Wang hongwei, 2004). The number of the meta-terms should be as few as possible. Furthermore the design of meta-terms had better independent to the domain that the ontology derived from. Thus meta-terms can help explain and define other concepts and terms listed in table 1. In our project the meta-terms consist of five elements, namely entity, relationship, role, attribute and state. Table 2 tells their meaning and notation.

Table 2 Meaning and Notation of Five Meta-Terms

Meta-terms	Meaning	Notation
Entity	The most basic element in modeling. All other concepts can be derived from it.	An entity can participate manifold relationships with other entities
Relationship	The situation reflecting association of two or more entity	Relationship itself is regarded as an entity so can participate other relationships
Role	The mode of entity participating relationship	In fact the meaning of role is an entity playing a role
Attribute	The relationship between two entities and showing such features within modeling scope that the value of the relationship is limited to an entity if one entity is given	In view of math an attribution is just a function
State	A kind of situation which includes a series of relationships and their value	For any state it can be expressed tenable or true

There are some of examples that can illustrate the meaning of the five elements. A person can be called an entity. Birth of date is his (her) attribute. A transaction can be defined a kind of contractual relationship made by two entities that exchange products with some price. Buyer and Seller are two roles respectively played by two entities in the trade relationship. “For sale” can be viewed as a state of the product.

2.2.2. Description of Customer Terms Based on Meta-Terms

The description of concepts and terms listed in table 1 by meta-terms is completely different from looking up dictionary. The function of the dictionary is just to tell people how to understand and apply vocabulary, while the description herein is to clarify and standardize relationships among concepts.

The following part just exhibits the description of some concepts and terms because of limitation of the paper size. The detailed information can refer to reference [5].

（1）PRODUCT：a kind of *role* acted by some goods, services or currency used for *transaction*

（2）ASKING PRICE：a kind of *role* acted by a quantity of currency used for exchanging *product* and put forwarded by *vendor* to *buyer* before *transaction*

（3）COMPETITOR：a kind of *role* acted by a *vendor* formed a *relationship* with another *vendor* who providing the associated *product*

（4）OWNERSHIP：a kind of droid *relationship* between a *legal entity* and another *entity*

（5）CUSTOMER RELATIONSHIP：the *relationship* between *vendor* and *customer*

（6）POTENTIAL CUSTOMER：an *entity* possibly becoming the *actual customer*

（7）LOST CUSTOMER：The *actual customer* broken off *transaction*

（8）SWITCHED CUSTOMER：The *lost customer* established *customer relationship* with *competitor*

（9）TRANSACTION：a kind *relationship* between two *entities* exchanging a benefit, service and a quantity of currency

（10）ITERATIVE PURCHASE：the same *product* is *purchased* from the same *vendor* for more than one time。

（11）CUSTOMER LIFETIME VALUE：The profit that *customer* brings for *vendor* in *customer lifetime*

The words with capital are concepts and terms to be defined by underlined and italic words that are concepts and terms of customer domain already defined. Some notations for the concepts are omitted.

Notice that the definition of any concept should not be confined to the exact profile. Various terms may be referred to in definition of one concept. For example, the definition of "switched customer" just involves two concepts: "lost customer" and "competitor". Which indicates that the cross way, not vertical way, is used for the definition.

Formalization of Customer Terms

Conceptualization of customer in CRM is just the first step to establish the customer ontology. Now a formalization tool is applied in order to help transform the customer terms described in natural language illustrated above into a normative and organized format. Thus those concepts and terms may be machine-readable, automatic reasoning and verification.

2.3. Selection of description language of formalization

Descriptive Logic (DL), also called concept representation language or term logic, is a cluster knowledge representation language system describing concepts and their structure relationship (Lan, 2001). It includes such three basic elements as concept, role and individual. Concept is a set of individuals or objectives and considered as the first-order predication. Role represents binary relationship between individuals and can define more complicated new concepts and roles by lots of constructors such as merging, extracting and role words except from prototype concepts and roles.

Here DL is selected as a description language of formalization for customer terms when three points are considered:

（1）simple structure, easy to be transformed to frame structure, coinciding with the cognition process；

（2）the ability to provide determinant reasoning service[7], in favor of verification of customer ontology；

（3）the ability to convert to XML or RDF convenient for communication though internet.

In addition, DL shows strong capability of representation and judgment, which could guarantee the reasoning algorithm must stop at some point and send back proper results.

2.4. Formalization of customer terms based on DL

The format of the formalization of terms can be organized as the ontology model M with seven elements shown below [8].

$$M=<T, X, TD, XD, AA, TC, TR>$$

T－term set，including class term and attribute term

X－instance set，as the set of individuals (instances)

TD－term definition set，used for defining terms in T

XD－instance declaration set including class and attribute instances declaration, used for declaring the instances of term

AA－attribute allocation set，allocating attributes for class terms

TC－term connotation set

TR－term restraining set

The process of formalization includes two steps, namely meta-terms formalization and customer terms formalization. Whichsoever step is taken all of the terms need to be put in the ontology model with seven elements by virtual of the term constructor in DL. The formalization of meta-terms is given as the following.

M=<{Entity, Relationship, Role, Attribute, State, have, participate, domain, range, belongTo, dataType, playedBy, paly, include, occurIn, in}，∅，∅，∅，{EntityM∀have.Attribute⊓∀participate.Relationship⊓∀play.Role ⊓ ∀in.State, RelationshipM∀domain.(Entity ⊓ ∃play.Role) ⊓ ∀range.(Entity ⊓ ∃play.Role), RoleM∃playedBy.Entity⊓∃occurIn.Relationship, AttributeM∀belongTo.Entity⊓∀dataType.Entity, StateM ∃include.(Relationship⊓∃range.Entity)}，{*tc*(Entity)=a fundamental thing in the domain being modeled, *tc*(Relationship)=the way that two or more Entities can be associated with each other, *tc*(Role)=the way in which an Entity participates in a Relationship, *tc*(Attribute)=a Relationship between two Entities with the following property: within the scope of interest of the model, for any particular attributed Entity the Relationship may exist with only one value Entity, *tc*(State)=a situation. the following is necessarily true of a State: it consists of a set of Relationships between particular Entities; it can be said to hold, or be true (and conversely to not hold or to be false)}，{RelationshipMEntity, RoleMEntity, StateMEntity, AttributeMRelationship, play≡palyedBy⁻, have≡belongTo⁻, participate≡(domain ⊔ range)⁻, belongToMdomain, dataTypeMrange}>

When the formalization model of meta-terms is established that of customer terms can be easily constructed by referring to the former and other recognized terms. The following gives several examples of the formalization model of customer terms. Ellipsis implies the term has already been formalized before.

- **（Lost Customer）** and **（Switched Customer）**

C=<{…,…,LostCustomer, SwitchedCustomer, enteringInto, breakingOff}，∅，{…,…, LostCustomer ≡Customer ⊓ ∃breakingOff. Transaction, SwitchedCustomer≡ LostCustomer ⊓ ∃isPurchasing.

(Product⊓∃isOfferedBy.Competitor)，∅，{…, …, }，{…, …, tc (LostCustomer)= the ActualCustome breaking off Transaction, tc (SwitchedCustomer)= the LostCustomer having CustomerRelationship with Competitor}，{…, …, SwitchedCustomerM LostCustomer}>

LostCustomer and SwitchedCustomer are both compound terms. LostCustomer ≡Customer ⊓ ∃ breakingOff. Transaction shows customer breaking off transaction. SwitchedCustomer≡ LostCustomer⊓∃isPurchasing. (Product⊓∃isOfferedBy.Competitor shows lost customer purchase product from competitor. tc (LostCustomer) and tc (SwitchedCustomer) are natural descriptive language of lost customer and switched customer. SwitchedCustomerM LostCustomer shows that switched customer is subclass of lost customer.

- **（Iterative Purchase）**

C=<{…,…, SameProduct, IterativePurchase, purchaseTime, productKind}，∅，{…,…}，∅，{…, …, IterativePurchaseM∃isPurchasing.SameProduct ⊓ ≥ 2,purchaseTime} ， { … , … , tc (IterativePurchase)=Purchase the same Product from the same Vendor for more than one time, }，{…, …}>

Here, one prototype class term SameProduct and two attribute terms are added. ≥ 2,purchaseTime shows purchase is more than twice. ≥2,productKind shows that product kind is at least two kinds. tc (IterativePurchase) and tc (CrossBuying) are natural language description of iterative purchase and cross purchase.

- **（customer lifetime）**and**（Customer Lifetime Value）**

C=<{ … , … , CustomerLifetime, Profit, CustomerLifetimeValue, }， ∅， { … , … , }， ∅， { … , … ,CustomerLifetimeM *T*:TimeInterval ⊓ ∃include.CustomerRelationship, CustomerLifetimeValueMProfit ⊓ ∃providedBy.(Customer ⊓ ∃have. CustomerLifetime)} ， { … , … , tc(CustomerLifetime)=the TimeInterval of CustomerRelationship, tc(CustomerLifetime Value)=the Profit that Customer brings for Vendor in CustomerLifetime}，{…, …}>

An atomic class term Profit is added in order to define a new term CustomerLifetimeValue, which is subclass of profit. *T*:TimeInterval⊓∃include.CustomerRelationship represents time interval of existed customer relationship. *T*:TimeInterval represents citation of time ontology developed by KSL ontology lab (Noy, 2001). Profit ⊓ ∃providedBy.(Customer ⊓ ∃have. CustomerLifetime) represents profit provided by customer in CustomerLifetimeValue. tc(CustomerLifetime) and tc(CustomerLifetime Value) are natural language description of CustomerLifetime and CustomerLifetimeValue.

Obviously, not all of the seven elements are deployed and XD is written as ∅, for example. Even though, it does not at all damage the formalization of customer terms. With the application in practice it will gradually be expanded and improved. However one must remind that any expansion of the model has to be followed by the verification of the terms in order to escape from inconsistency.

Conclusion

The paper discusses the formalization of customer terms in detail according to ontology framework. In fact modeling customer ontology in CRM is very worthy of further exploring because acquirement of customer knowledge and information sharing semantically have played important role for the implementation of CRM strategy. However many things such as maintenance and verification of customer ontology remain unsolved completely yet, much still less application of customer ontology. People have not made consensus in customer scope,

concepts and terms, information particle and formalization tool as yet. In addition there exist several approaches about how to establish customer. Some scholars suggest introducing behavior ontology as an alternative to coordinate the dilemma of conceptualization for current customer ontology. Completion is another problem to conceptualization since lack of structured method. In all so many researches needs to be done in order to construct a uniform communication platform. The conclusion derived from this paper is also just a trial.

On the other hand if effective approach to those problems can be found out or designed customer ontology can provide big chances for the enterprise to make good use of the information resources with the view of semantic relation. A real industrial standard, also a good customer ontology model, in information system modeling and process modeling can be expected to reflect customer demand and features properly and comprehensively. Of course this need concerted efforts of experts in management and knowledge engineering area to iteratively improve the availability of customer ontology.

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